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Effects of Two Backpack Weight Distributions on Perceptual and Physiological Measures During Walking

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Effects Of Two Backpack Weight Distributions
On Perceptual And Physiological Measures During Walking

A Thesis Presented to
The Faculty of the Department of Physical Education and Recreation
Western Kentucky University
Bowling Green, Kentucky

In Partial Fulfillment
Of the Requirements for the Degree
Masters of Science

By
Katelyn Wells-Fahling
July 2002

Effects Of Two Backpack Weight Distributions
On Perceptual And Physiological Measures During Walking

Date Recommended July 10, 2002

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Dean, Graduate Studies and Research

10-7-02
Date

Table of Contents

Chapter		
I	Statement of the Problem.....	9
	Introduction.....	9
	Significance of the study.....	11
	Hypothesis.....	11
	Purpose.....	11
	Limitations.....	11
II	Review of Literature.....	12
	Methods of Load Carriage and the Physiological Response.....	12
	Double Pack Carriage of Load and the Physiological Response.....	12
	Back Pack Design and Physiological Response.....	13
	Weight Distribution of Backpack and the Physiological Response.....	14
	Weight Distribution and Non-Physiological Assessments.....	15
	Rate of Perceived Exertion.....	16
	Local and Central Factors Effecting Perceived Exertion.....	16
	Local Factors as Input for Perceived Exertion.....	17
	Differentiated Ratings of Perceived Exertion.....	18
	RPE and Backpack Design.....	18
III	Methodology.....	20
	Subjects.....	20
	Screening Procedures.....	20
	Experimental Procedure.....	21
	Session 1.....	21
	Session 2.....	23
	Survey.....	23
	Data Analysis.....	23
IV	Results.....	24
	Backpack Distribution.....	24
	Survey.....	24
V	Discussion.....	25
	Summary.....	29
VI	Tables/Graphs.....	30
VII	Appendices.....	37
IIX	Bibliography.....	50

List of Graphs/Tables

1	Descriptive Characteristics	I
2	Heart Rate.....	II
3	RPE-Back.....	III
4	RPE-Shoulders.....	IV
5	RPE-Legs.....	V
6	RPE-Overall.....	VI

Appendices

Appendix	Page
Survey	38
RPE Scale	39
Houston VO ₂ max equation	41
Risk Stratification	42
Informed Consent	44
Par-Q	48
Data Collection	49

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Effects Of Two Backpack Weight Distributions
On Perceptual And Physiological Measures During Walking

Directed by: J.M. Green, S. Spencer, T.R. Crews, R. Deere

Department of Physical Education and Recreation

Backpack weight distribution may affect economy by conserving energy and thus potentially prolonging fatigue. Research has not however examined effects of backpack weight distribution on subjective measures of intensity and comfort. Heart rate (HR) and overall and differentiated Ratings of Perceived Exertion (RPE) were examined during simulated backpacking with differentially weighted backpacks.

Volunteers (n=27) completed two simulated hiking trials on a treadmill. Trials consisted of 15 minutes walking at 0% grade followed by 15 minutes walking at 10% grade at 2.5 mph (males) or 2.0 mph (females). Subjects wore an internal frame backpack packed to contain 25% of their individual body weight). In a counterbalanced order, packs were placed with either a high weight distribution (HWD) (3:1:1 ratio) placing more weight near the shoulders, and a low weight distribution (LWD) (1:1:3 ratio) placing more weight near the hips. Heart rate (HR), RPE-Overall, RPE-Legs, RPE-Shoulders, and RPE-Back were recorded every three minutes and compared between trials using repeated measures ANOVA.

HR between HWD and LWD was similar at 0% as well as 10%. Overall and differentiated RPE's were not significantly different between (HWD vs. LWD) at 0% or 10%. Results suggest backpack weight distribution (HWD vs. LWD) does not

significantly influence HR and perceptual measures during simulated hiking at a 0% or 10% grade.

Chapter I

Statement of Problem

Introduction

Backpacks are used in a variety of activities such as leisure, industrial and military pursuits. In most studies concerning backpacking and different modes of load carriage, efficiency is a primary objective (Datta and Ramanathan 1971, Bedale 1924, Legg, Ramsey, and Knowles 1992, Legg and Mahanty 1985, Legg 1985). Physiological variables such as oxygen uptake, minute ventilation, muscle activation levels and heart rate, and non-physiological responses, such as skin irritation, are all factors that aid in distinguishing an efficient and comfortable mode of load carriage (Datta and Ramanathan 1971, Bedale 1924, Legg, Ramsey, and Knowles 1992, Legg and Mahanty 1985, Legg 1985). Furthermore, subjective measures such as ratings of perceived exertion (RPE) may aid in determining an efficient and comfortable mode of load carriage (Mahanty 1984).

Research suggests that trunk carriage is physiologically the most economical compared to modes such as head, shoulder, hands rucksack, double pack, rice bag, serpa, and yoke (Datta and Ramanathan 1971, Bedale 1924, Legg, Ramsey, and Knowles 1992). In principle, an ideal method of load carriage should induce stability, bring the center of gravity of the load as close as possible to that of the body and make use of larger muscle groups (Legg 1985).

Trunk carriage of a load consisting of weight placed on the front and back torso is more efficient than weight placed solely on the back (Datta and

Ramanathan 1971, Bedale 1924, Mahanty 1984). However, due to the impracticality of this design, research has concentrated on the physiological efficiency of other backpack designs (Mahanty 1984, Kirk and Schneider 1992, Kinnear and Cundiff 1974). Internal and external frame backpacks and hip belts are components of backpack technology that have been investigated to determine if varying backpack designs influences economy mode of load carriage. While oxygen uptake, ventilation, and heart rate are not significantly different between internal and external frame backpacks (Kirk and Schneider 1992, Mahanty 1984), the use of hip belts results in a significantly lower heart rate response (Kinnear and Cundiff 1974).

Variations in weight placement within the backpack do not influence physiological responses (Aune 1977, Bryce 1977). However, metabolic measurements are not the only factors to consider when evaluating backpacking (Bobet and Norman 1982). In addition to oxygen uptake, heart rate, and blood lactate as indicators of exercise intensity, one also can use RPE to evaluate intensity (McArdle and Katch 1996). Borg developed RPE to relate objective measures of physical output to subjective measures of intensity (Monahan 1988). The 15-point exertion scale has central intervals that are determined by verbal expressions and typically increase linearly with exercise intensity (Pandolf 1983). In addition, RPE values may be differentiated by rating anatomical areas such as legs, chest, or back. Pandolf (1978) suggests an experimental model of differentiated RPE's may provide a more precise examination of local and central factors, in comparison to the single undifferentiated overall RPE.

Significance of the study

Previous studies have investigated the effects of carrying a load and subjective measures using different designs of backpacks (Legg 1997, Kirk and Schneider 1992, Mahanty 1984). However, few studies have assessed the potential influences of weight distribution of a backpack on overall and differentiated RPE estimations. Legg (1997) stated that subjective perceptual measures might provide useful information about small differences in backpack design when physiological comparisons fail to differentiate between designs. However, no data was presented to support this theory.

Hypothesis/Purpose

Because the ideal method of load carriage should induce stability by bringing the center of gravity of the load as close as possible to that of the body and make use of the large muscle mass (Legg 1985), low weight distribution compared to high distribution may result in a lower differentiated overall, back, leg, and shoulder RPE estimation. Because previous research has not rigorously addressed this possibility, the purposes of this study were to examine overall and differentiated RPE estimation and heart rate between two different backpack distributions (high vs. low), during simulated hiking at 0% and 10% grade.

Limitations

Limitations include limited subject pool and the use of simulated hiking rather than outdoor environment.

Chapter II

Review of Literature

Methods of load carriage and physiological response

Many researchers have examined different modes of load carriage and associated physiological responses. Datta and Ramanathan (1971) investigated seven modes of carrying an identical load by method of head, rucksack, double pack, rice bag, serpa, yoke, and hands. Minute ventilation, oxygen consumption, and heart rate were recorded. The double pack, consisting of weight placed on the front and back torso, showed a lower oxygen uptake, heart rate and minute ventilation, when compared to all other modes of load carriage. Bedale (1924) found energy expenditure to be significantly lower when carrying a yoke across the shoulders than carrying a load on the hips or hands.

Legg, Ramsey, and Knowles (1992) examined the metabolic cost of backpack and shoulder load carriage. A 26 kg load was placed on a backpack or carried on each shoulder. The relative oxygen cost of back packing (4.3-4.7% VO_2 max) as well as heart rate during backpacking were significantly lower than shoulder carriage.

Double pack carriage of load and physiological response

Datta and Ramanathan (1971), Bedale (1924), Legg, Ramsey, and Knowles (1992) determined that load carriage on the trunk was the most economical mode. In principle, an optimum method of load carriage should induce stability by bringing the center of gravity of the load as close as possible to that of the body and make use of the large muscle mass (Legg 1985). Datta and Ramanathan (1971), Legg and Mahanty (1985) and Mahanty (1984) found the double pack,

consisting of weight placed on the front and back torso, was more economical than the rucksack, consisting of weight placed solely on the back. Although, the use of double pack is physiologically preeminent, this method may be impractical in many industrial, military or leisure situations (Legg, Ramsey, and Knowles, 1992). Objects on the chest may impair vision, limit maneuverability and possibly restrict breathing (Legg and Mahanty 1985).

Back Pack Designs and physiological response

The elimination of double pack designs for practical use resulted in the search to determine the most economical and practical mode of load carriage using a backpack. Mahanty (1984) compared backpacks with frames, no frames, waist belts, weighted toes, double pack, and a trunk jacket that consisted of military fragmentation jackets with weight added to the pockets. Physiological measures such as oxygen uptake, minute ventilation, heart rate, and subjective strain such as RPE were analyzed. Backpacks with frames, no frames, waist belts, weighted toes, and a trunk jacket did not generate a significant difference for oxygen uptake, minute ventilation, and heart rate. However, the weighted toe method resulted in a significantly greater physiological strain and RPE when compared to the other four methods. Additionally, physiological strain for the double pack was significantly lower compared to the other methods of trunk carriage.

As seen in previous studies (Datta and Ramanathan 1971, Bedale 1924, Legg, Ramsey, and Knowles 1992), Mahanty (1984) also found lower physiological strain associated with using a double pack system when compared to other methods of load carriage.

Metabolic, cardiorespiratory, and perceptual measure were recorded while 11 females carried an internal and external frame backpack (Kirk and Schneider, 1992). The subjects walked on the treadmill for one hour with 33 % of their body weight added to a backpack, and the grade alternated every 15 minutes. Oxygen uptake, minute ventilation, and heart rate were not significantly different between backpack type. RPE estimations for chest, shoulder, and legs increased with exercise time and treadmill slope, but were not significantly different between internal and external frame backpacks.

Energy expenditure associated with a traditional rucksack and the AARN rucksack, which incorporates front balance pockets similar to the double pack system, was assessed by Lloyd and Cooke (2000). For AARN, oxygen uptake was significantly lower ($17.28 (7.46) \text{ ml} \cdot \text{kg}^{-1} \cdot \text{min}$) than the traditional rucksack ($18.20 (7.84) \text{ ml} \cdot \text{kg}^{-1} \cdot \text{min}$).

The effects of padded hip belts on heart rate were investigated by Kinnear and Cundiff (1974). The use of hip belts resulted in a significantly lower heart rate. Results showed females were greatly affected by the use of hip belts. Kinnear and Cundiff suggest, “ Padded hip belts benefit all wearers, those who gain the most are females, and those males who are not heavily muscled through the upper torso.”

Weight Distribution of Back Pack and Physiological Response

Aune (1977) examined backpack distribution and its effect on heart rate. Five male and six female subjects walked on a treadmill for 25 minutes with a 3% increase in grade every five minutes. Male subjects walked at 3.4 mph and female

subjects at 2.8. The males' backpack was 40 lbs with a 26:14 lb ratio, and the females' pack was 25 lbs with a 16:9 lb weight ratio. Two trials were conducted with both high-to-low and low-to-high weight ratios. The results found no significant difference in heart rate when comparing the high versus low weight distribution of a backpack. Aune stated that some subjects voluntarily reported a preference for one techniques. However, no data was presented.

Bryce (1977) also investigated physiological response and load placement. Arm carriage and high and low placement of weight in a backpack was investigated in a controlled indoor and outdoor environment. The high load was more economical by 80%. The findings indicate physiological differences in extreme carrying positions were significant.

Weight distribution and non-physiological assessments

Other variables besides physiological factors may influence comfort in load carriage (Vacheron 1999). For example, Holewijn (1999) found that load transferred to the waist reduced the pressures on the shoulders. This finding is important because skin irritation may cause subjects to perceive the load heavier and possibly lead to premature exhaustion due to localized pain and fatigue.

Bobet and Norman (1982) looked at the effect of load placement and muscle activation measuring using EMG measurements and weight placed on the mid-back or above the shoulders. Eleven subjects walked on a level surface at 5.6 km with a load of 19.5 kg. A specially designed backpack was used to concentrate force on the two areas. EMG levels on the shoulder area were significantly higher than the mid back. There was no significant difference for heart rate between the

two placements. Bobet and Norman (1982) conclude“ that the metabolic measures alone are not sufficient to adequately assess tasks which evoke primarily local muscle demands.” Therefore there is a need to supplement measures of heart rate and oxygen uptake with other variables in order to rigorously examine the differences in load placement and investigate the potential effects on perceived comfort and intensity.

Rate of perceived exertion

In addition to oxygen uptake, heart rate, and blood lactate as indicators of exercise intensity, one also can use ratings of perceived exertion (McArdle and Katch 1996). In the 1960's, Borg developed a scale to relate objectives measures of physical output to subjective measures (Monahan 1988). The 15-point exertion scale has central intervals that are determined by verbal expressions which tend to increase linearly with exercise intensity and heart rate (Pandolf 1983). “Borg has determined that perceived exertion and physical load have a reliability coefficient of .90, and the submaximal RPE is more accurate than submaximal heart rate in predicting maximal work capacity” (Monahan 1988).

Local and central factors affecting perceived exertion

Borg acknowledged that perception of effort was dependent upon input from both the musculature and the systems of circulation. He also proposed that perceived exertion is most forcibly influenced by the adaptations of the circulatory system (Mihevic 1981)

Eklom and Goldbard (1971) challenged Borg's concept that RPE was largely affected by the circulatory system, arguing that local muscular strain

during cycling was the principal foundation for perceptual response. They proposed that the perception of effort was governed primarily by local factors, such as the feeling of strain in muscles, with secondary input provided by the pulmonary ventilation and circulation. Therefore, the terms central referring to the pulmonary ventilation and circulation and local referring to the feeling of strain in muscles have been unanimously adopted within the exertion literature (Mihevic 1981).

Central factors as input for perceived exertion

A majority of the information about the support of central factors has been directed toward validating Borg's perceived exertion model and its relation to heart rate (Mihevic 1981). Other central limitations such as ventilatory minute volume (V_E), respiration rate (RR), and oxygen consumption (VO_2) have been investigated regarding their contribution to the input for central factors (Mihevic 1981). For example, studies have found that perceived exertion is directly related to ventilation and respiratory rate (Morgan (1973) and Morgan and Pollock (1977). These studies supported the importance of V_E and RR in regards to perceived exertion. However, literature does not suggest that any input from any one particular central factor results in a greater perceived exertion (Mihevic 1981).

Local factors as input for perceived exertion

“The classification of physiological or muscular response as a local factor, is important for perception of effort, and is based on the mediation of feelings of strain in the exercising muscle” (Ekblom and Goldbarg 1971). Muscle lactate

levels, Golgi tendon activity, and general muscle sensations can contribute to the factors that affect RPE (Mihevic 1981). Research has found that fatigue and perceived exertion are related to lactate response (Mihevic 1981). However, actual fatigue or perceived exertion due to lactate levels would not be applicable in all circumstances, and is not the only factor that would contribute to a greater RPE.

Differentiated ratings of perceived exertion

Locating the primary source of perceived exertion has led to a method that attempts to identify the perceived effort in diminutive areas of the body. The differences in local and central factors, as regards RPE, are identified as differentiated RPE. Differentiated RPE values are obtained by rating anatomical areas such as legs, chest, or back. Pandolf (1978) suggests an experimental model of differentiate RPE may provide a precise examination of local and central factors, in comparison to the single undifferentiated overall RPE.

RPE and backpack designs

Previous studies have investigated the effects of carrying a load and RPE using different designs of backpacks (Legg 1997). Kirk and Schneider (1992) used differentiated RPE when distinguishing between internal and external frames. In that study RPE chest plateaued at 30 minutes during a 60 minute trial, while shoulders and legs RPE estimation continued to increase with time. Legg and Mahanty (1985) also evaluated RPE when distinguishing between backpack with and without frame, load placed in backpack and attached to hip belts, front backpack and a military trunk jacket. Mahanty (1985) found no significant

difference in RPE estimation among 5 modes of carrying a load close to the trunk. Legg and Mahanty (1985) reported lower RPE values when load was carried in a front backpack or trunk type system than when carried in a backpack. However, RPE was not affected by internal and external backpack type.

Because previous research has failed to examine the differences between backpack distribution and overall and differentiated RPE between two different backpack distributions (high vs. low), during walking, the purpose of this study was to compare HR and RPE responses between two backpack packing techniques. Low weight distribution may result in a lower differentiated overall, back, leg, and shoulder RPE response. It may produce a more ideal method of load carriage inducing stability by bringing the center of gravity of the load as close as possible to that of the body and making use of the large muscle mass (Legg 1985). Variations in weight distribution may also generate differences in specific RPE responses because of differences in localized fatigue. For example, shoulder fatigue (and therefore RPE-shoulder) may be greater when a large percentage of weight is carried near the shoulders.

Chapter III

Methodology

Subjects

Subjects for the study were volunteers between the ages of 18-45. Twenty-seven subjects participated, (14 female and 13 male).

Screening procedures

Screening procedures (discussed below) were utilized to help ensure safe participation. Subjects were contacted by phone but only after they have expressed an interest in participating.

Prior to participation, subjects signed a written informed consent (Appendix V) outlining requirements, as well as potential risks and benefits resulting from participating. Additionally, each participant completed a "Physical Activity Readiness Questionnaire" and a tool used for stratifying subjects (based on risk for exercise participation) according to guidelines of the American College of Sports Medicine (2000). A sample of each of these tools is provided (Appendix VI). These tools are designed to screen individuals who may be at increased risk for complications as a result of taking part in vigorous physical activity. The stratification tool classifies each person as "low risk", "moderate risk", or "high risk" based on various criteria. In the proposed study, only "low risk" subjects were allowed to participate. Subjects were instructed that they could withdraw from the study at any time.

Experimental procedure

Laboratory Testing (All testing was completed at the Human Performance Laboratory Smith Stadium, Western Kentucky University)

Lab Session 1

Descriptive Data Collection

Descriptive data was collected immediately prior to the initial exercise trial. Subjects reported to the lab at a designated time. An explanation of the study, initial screening procedures (questionnaires), and instructions regarding exercise trials were discussed. Subjects were assessed for age, height, 3-site body fat percentage (3 site skin fold technique {Appendix VII}), aerobic fitness (Houston non-exercise VO₂ max {Appendix III}) and weight.

Backpack fitting

The backpack was of the internal frame design. A medium or large frame backpack was used for all subjects. Backpack size and fitting guidelines were used to determine the subject's individual backpack size, shoulder strap length and hip pad width.

Each subject's backpack was packed to weigh 20-25% of his or her body weight (Roberts 1989). The backpack's weight distribution was dispersed in the backpack's top, middle, and lower compartments. The backpacks were filled with identical equipment such as tents, sleeping bags and lead shot (for achieving target pack weight). Gear was placed in three compartments to achieve a 3:1:1

high to low weight ratio, or a 1:1:3 low to high weight ratio. Total pack weight was identified between trials within subjects.

Treadmill Testing

Each session was a 30-minute treadmill walk with either high or low weight distribution backpack. A Polar heart monitor was worn during testing. Males walked on the treadmill 2.5 miles per hour, and 2.0 miles per hour was the setting used for females. The elevation of the treadmill was 0 % for fifteen minutes followed by 10% at fifteen minutes for a total of 30 minutes. Before subjects began exercising, a verbal description and explanation of the RPE scale was given to each subject (appendix II). Every three minutes, in counterbalanced order, during treadmill testing subjects were asked to verbally estimate their overall feelings of exertion (RPE-O) and feelings of exertion in their legs (RPE-L), back (RPE-B), and shoulders (RPE-S) by using a copy of Borg's RPE scale (appendix II) HR response ($\text{b} \cdot \text{min}^{-1}$) was evaluated using a Polar monitor. The treadmill session was concluded with a five- minute cool down session without a backpack.

Testing was terminated when *any* of the following criteria were met (based on American College of Sports Medicine Guidelines 2000):

- a) The subject requested the test be stopped (for any reason)
- b) The subject showed signs or symptoms that indicate the exercise test should be stopped (according to the American College of Sports Medicine Guidelines, 2000)
- c) Testers felt for any reason it was unsafe for the subject to continue

Lab Session 2.

This session took place within 4 days of Lab session 1. Treadmill testing protocol of Lab session 1 was repeated, however with the alternate backpack weight distribution being utilized. High and low weight ratio testing was counterbalanced to control for the effects of ordering.

Following the two testing sessions, subjects were asked to complete a survey that included questions regarding comfort level and preference.

(Appendix I)

Data analysis

Means and standard deviations were calculated for descriptive information.

(Table I)

Heart rate and RPE-Overall, RPE-Legs, RPE-Shoulders, and RPE-Back were recorded every 3 minutes and analyzed at 0% and 10% separately using a 4 (RPE) x 2 (pack distribution) repeated measures ANOVA for each situation. Results were considered significant at $p \leq 0.05$.

Chapter IV Results

Descriptive data

Descriptive data is presented on Table I.

Heart rate

Statistical analysis (2 (pack type) x 2 (incline) repeated measures ANOVA) found no significant difference in heart rate response between different backpack distributions at 0% or at 10% grade. (Figures II)

RPE Shoulders

There was no significance for RPE-overall between LWD and HWD at 0% or 10% incline. (Figures III)

RPE Back

There was no significance for RPE-back between LWD and HWD at 0% or 10% incline. (Figures IV)

RPE Legs

There was no significance for RPE-legs between LWD and HWD at 0% or 10% incline. (Figures V)

RPE Overall

There was no significance for RPE-overall between LWD and HWD at 0% or 10% incline. (Figure VI)

Survey

Twenty-two subjects completed a survey recording their preference between a high vs. low weight distribution backpack. Findings found show 60% of the subjects overall preferred the low weight distribution, and 40% preferred the high weight distribution.

ChapterV

Discussion/Conclusion

Previous research comparing methods of load carriage has found trunk carriage to be the most economical (Data and Ramanathan 1971, Bedale 1924, Legg, Ramsey, and Knowles 1992, Legg and Mahanty 1985, Legg 1985). Above all, placing weight on the front and back torso is more economical than placing weight solely on the back (Data and Ramanathan 1971, Bedale 1924, Mahanty 1984). However, due to the impracticality of this design, research has concentrated on differences in other backpack designs and packing techniques (Mahanty 1984, Kirk and Schneider 1992, Kinnear and Cundiff 1974). Internal and External frame backpacks and hip belts are components of backpack technology that have been investigated to determine if varying backpack design results in a more economical mode of load carriage. Oxygen uptake, ventilation, and heart rate are not significantly different between internal and external frame backpacks (Kirk and Schneider 1992, Mahanty 1984), the use of hip belts results in a significantly lower heart rate response when compared to a backpack without hip belts (Kinnear and Cundiff 1974).

Aune (1977) and Bryce (1977) found no significant difference in heart rate when comparing high vs. low weight distribution. Variations in weight placement within the backpack may not influence physiological responses (Aune 1977, Bryce 1977). However, metabolic measurements are not the only factors to

consider when evaluating backpacking especially when differences in backpack distributions are not drastic enough to influence physiological changes but may influence comfort or subjective fatigue (Bobet and Norman 1982).

In addition to physiological variables, subjective measures should be considered when evaluating comfort. For example, in addition to oxygen uptake, heart rate, and blood lactate as indicators of exercise intensity, one also can use ratings of perceived exertion (RPE) to assess exercise intensity (Mc Ardle and Katch 1996). Previous research involving backpacking and RPE, found these measured to be beneficial when physiological measures were less applicable (Legg 1997, Kirk and Schneider 1992, Legg and Mahanty 1985). However, previous research has failed to examine subjective measures when determining an economical and comfortable backpack weight distribution. Because previous research was limited, the current study compared HR response and overall and differentiated RPE between high and low weight distribution-packing technique.

Results show that backpack weight distribution does not affect overall or differentiated RPE or heart rate during simulated hiking. Heart rate and RPE share a .82 correlation in previous research (Morgan 1973, Dubbar 1992). Because heart rate response was not significantly different (Figure II), it is assumed that subjects were at a similar intensity during LWD and HWD, and it is not surprising that pack distribution did not have a profound impact on RPE

responses. The differences were not significant between the LWD and HWD physiologically (HR) or subjectively (RPE).

Reasons for no significant differences between LWD and LWD backpack distributions are speculative. For example, a forward lean (especially at a 10% incline) may have relieved a portion of the strain at the shoulders by aligning the pack's weight over the hips. Differences in differentiated RPE and RPE overall may have been altered due to posture adjustments. HWD may have placed additional strain on the shoulders; however, some subjects may have relieved the shoulder strain by placing thumbs under the straps. Alleviating shoulder strain could have caused similar RPE-shoulders responses, which potentially would have otherwise been greater during HWD because of added strain and fatigue at the shoulders.

RPE-back may have also been altered due on self-adjusted body positioning. A forward body lean may relieve muscle strain that is common with trunk stabilization. However, EMG levels and changes in body positioning were not monitored in the current study. Therefore, it cannot be concluded that increased muscle activity and fatigue, due to an adjusted body position, was responsible for similar RPE responses at LWD and HWD.

RPE-legs were one measure that was pronounced in some subjects at a LWD. Subjects complained of hip flexor fatigue and/or irritation from the hip belt, especially at 10% incline. The LWD may have placed excessive weight on the hip

region, therefore adding strain that caused irritation. However, the mean data suggest high RPE-legs at LWD was not pronounced enough to elicit a significant difference.

Other variables may have contributed to the lack of differences between LWD and HWD. The current study utilized twenty-five percent of an individual's body weight for pack weight. Twenty-five percent may not have been large enough to detect a significant difference between backpack distributions, a heavier pack may have generated different results. In addition, these backpack ratios (besides 3:1:1) may produce greater differences in RPE.

In addition to the RPE, twenty-two subjects participated in a survey that regarding preference between LWD and HWD. Results show 60% of the subjects (n= 13) preferred the LWD and 40% (n=9) preferred the HWD. This additional measure validated a nonsignificant preference between high vs. low distribution backpacks.

From a practical standpoint, this study suggests that high or low weight placement within a backpack does not affect heart rate or overall or differentiated RPE responses. Therefore, backpacking guides and manuals suggesting packing technique as regards to high or low distribution should suggest that gear be placed within the backpack for optimal accessibility and personal preference with special consideration to perceived comfort.

Summary

In summary, the present study found no significant difference in HR or RPE responses between high vs. low backpack weight distribution at 0% or 10% grade when packs were 25% of individual's body weight. Because of the lack of differences in the variables, backpacking guides and manuals should suggest gear be placed within the backpack for optimal accessibility, personal preference, and comfort.

Future research should investigate potential EMG differences between HWD and LWD. Biomechanical analyses and posture alignment may also be useful in determining how individuals compensate for load placement on the trunk at a LWD or HWD at different inclines. Additionally, relative differences in backpack weight and alternative weight ratio packing techniques should be investigated may these produce variations in RPE response or HR.

Tables/Graphs

Figure I-II-III-IV-V

Figure I. Descriptive characteristics

Variable	Mean	Standard deviation
Age (yrs.)		
Male	21.4	1.5
Female	19.7	1.5
Height (cm)		
Male	70.6	3.9
Female	67.0	2.3
Weight (kg)		
Male	83.0	20.5
Female	66.7	12.1
VO ₂ ml/kg/min		
Male	52.0	6.7
Female	40.3	4.3
Body Fat (%)		
Male	13.9	7.4
Female	24.6	4.9

Figure II. Heart rate responses between LWD and HWD at 0% and 10%

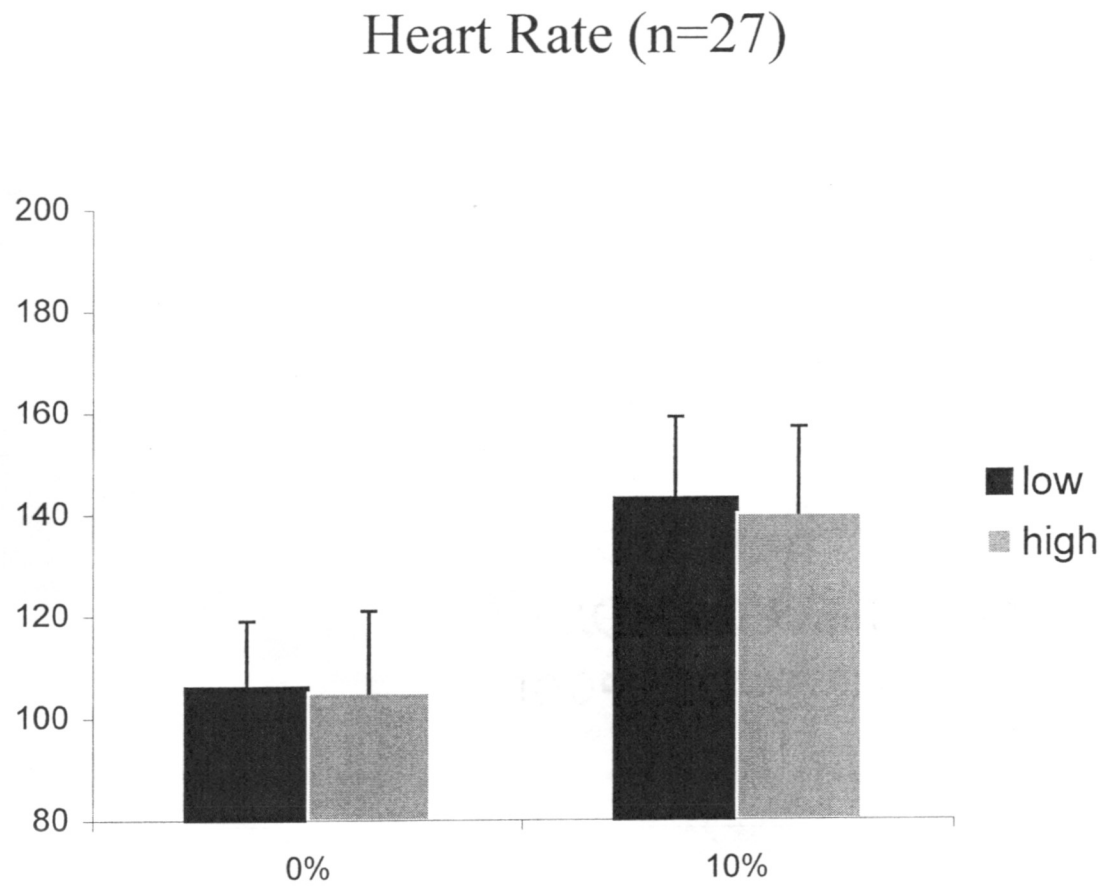


Figure III. RPE- shoulders responses between LWD and HWD at 0% and 10%

RPE-Shoulders (n=27)

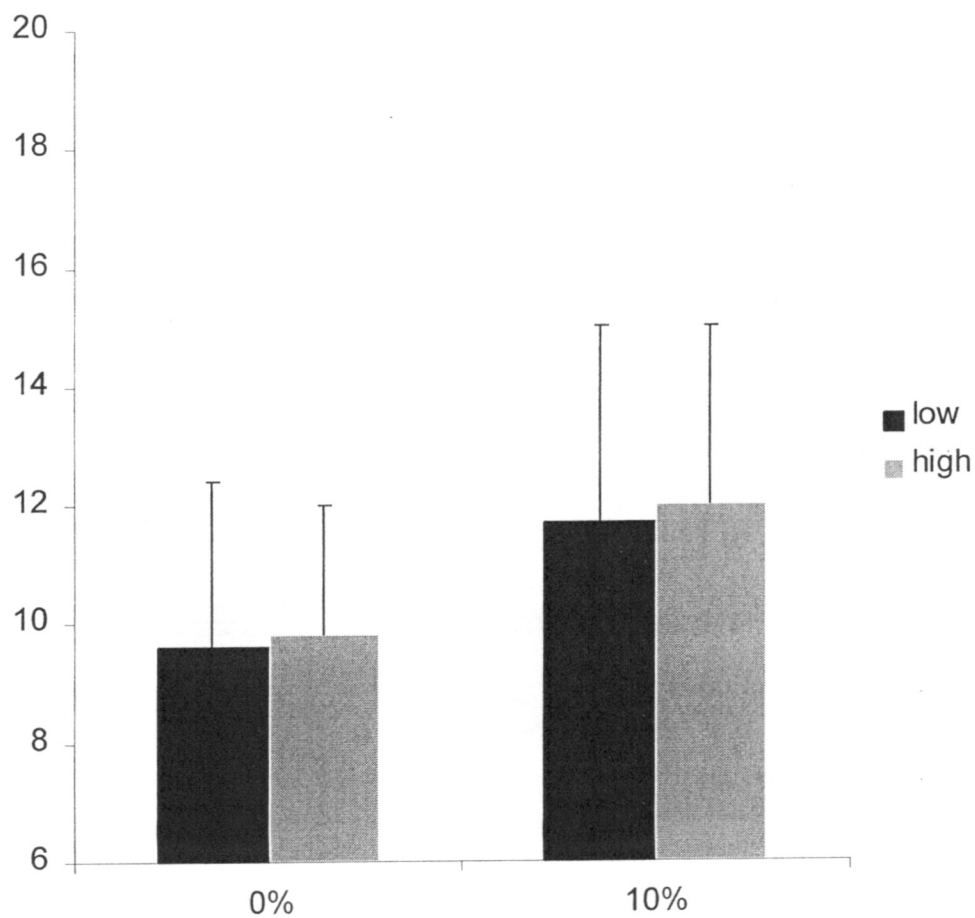


Figure IV. RPE- back responses between LWD and HWD at 0% and 10%

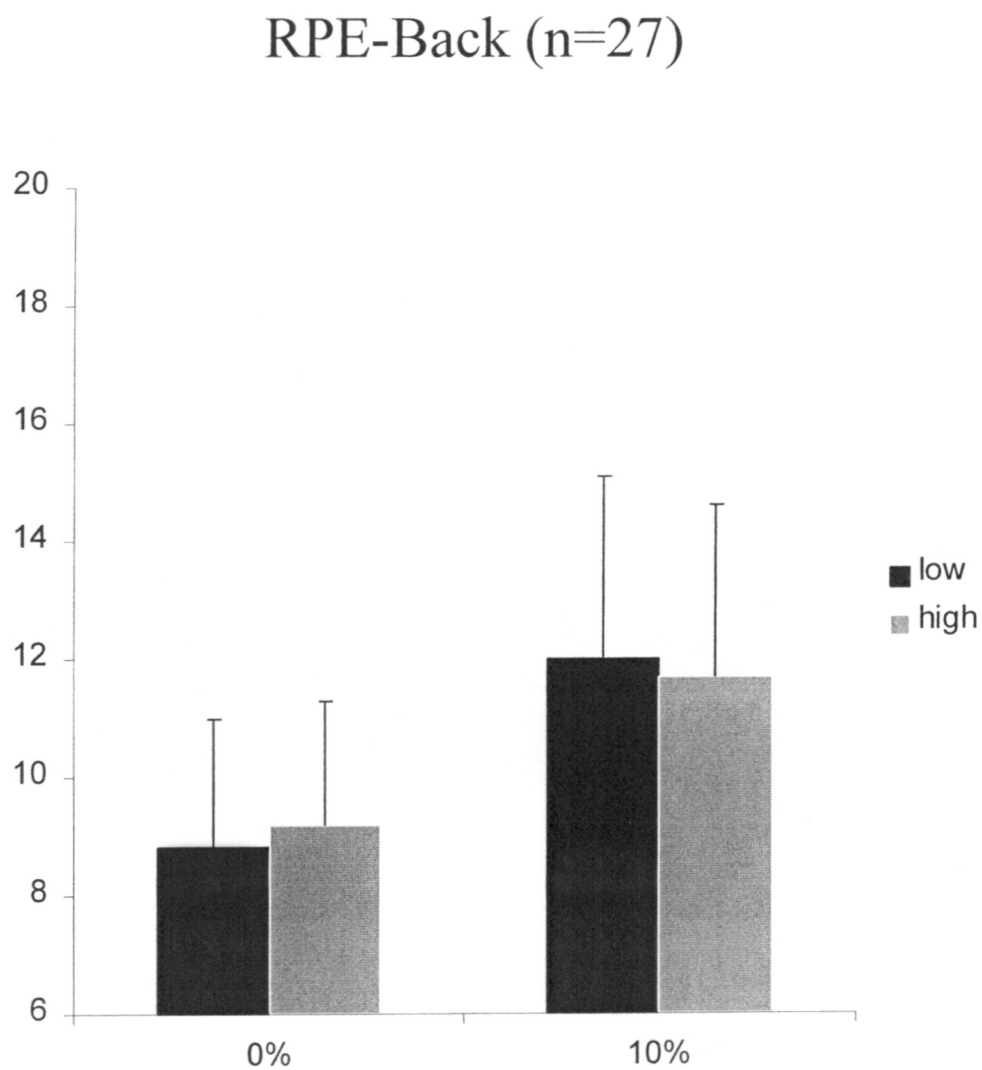


Figure V. RPE- legs responses between LWD and HWD at 0% and 10%

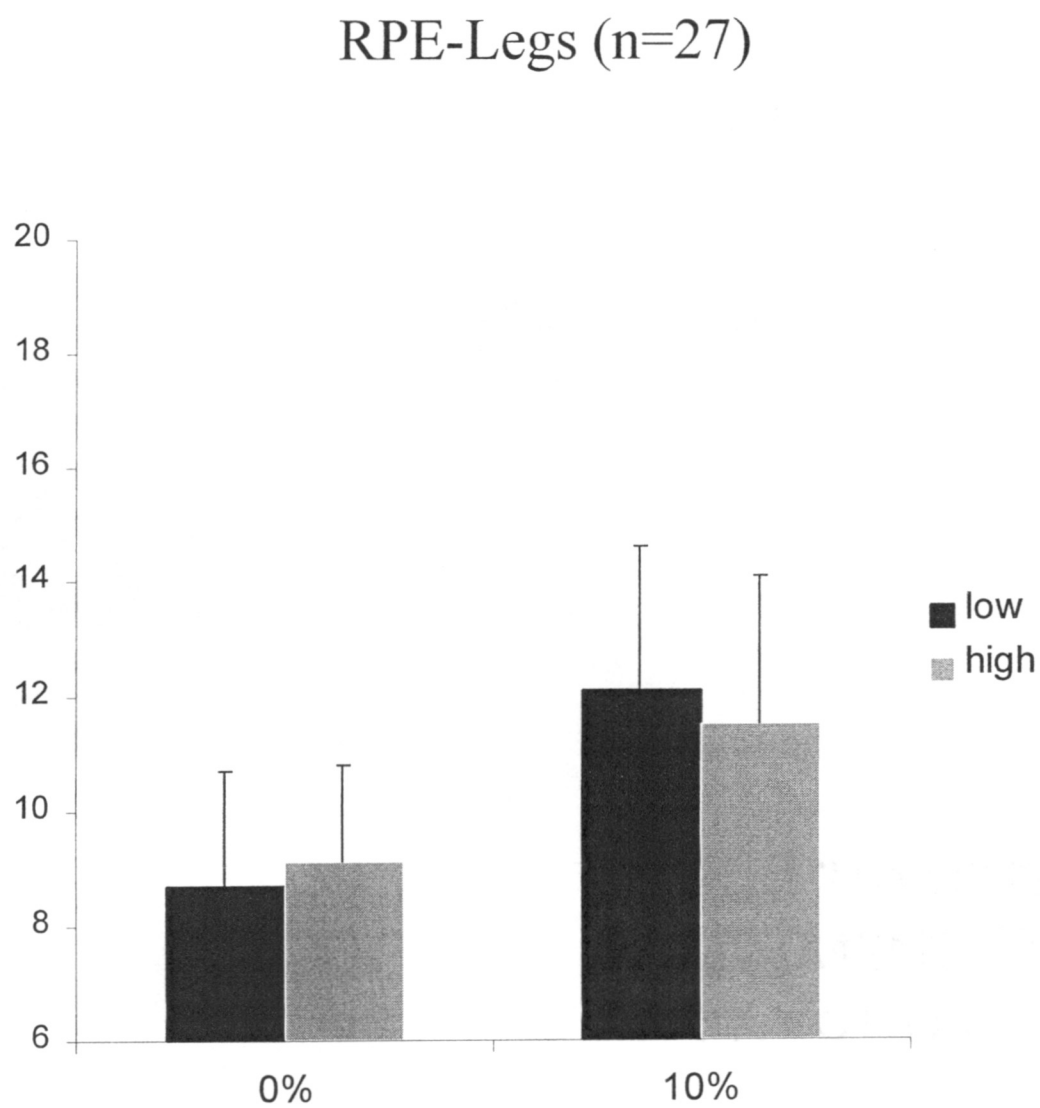
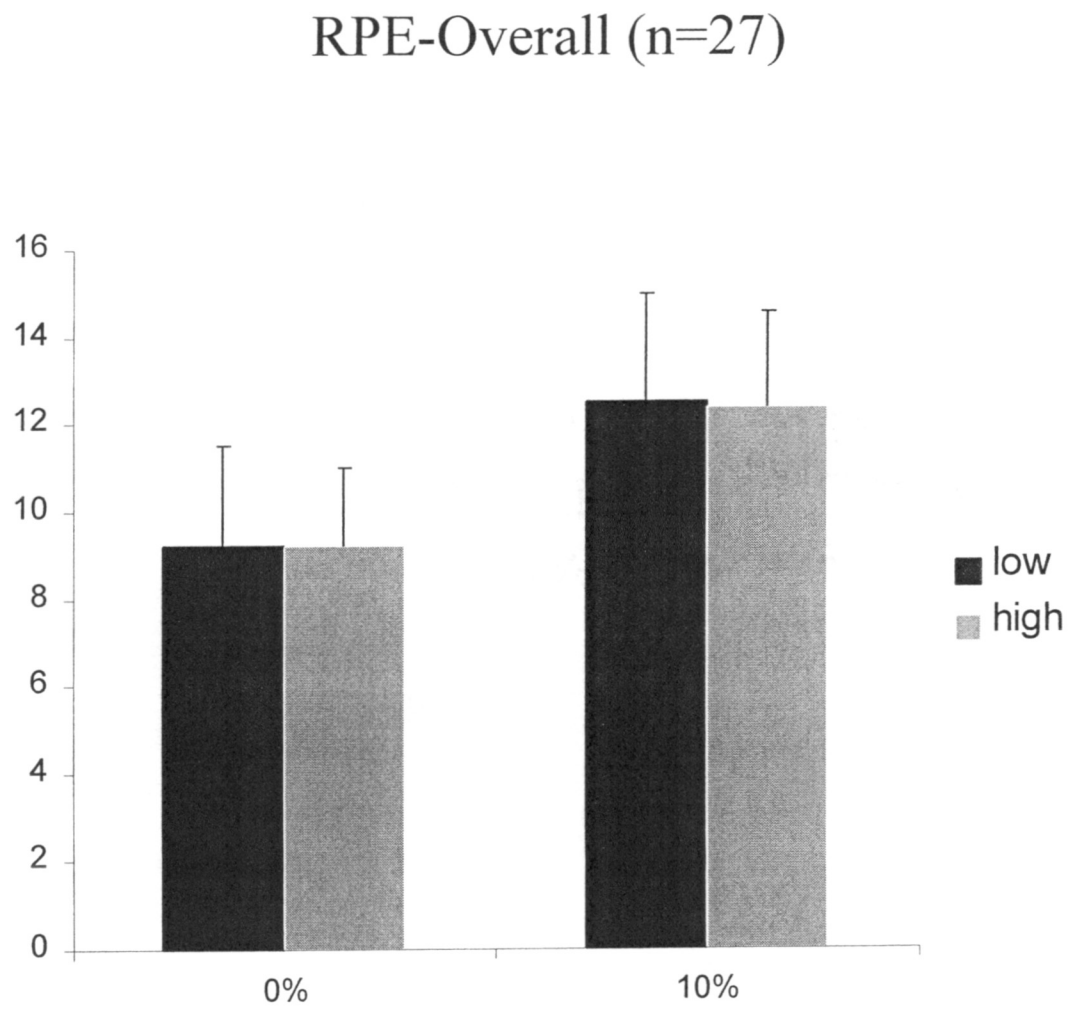


Figure VI. RPE- OVERALL responses between LWD and HWD at 0% and 10%



Appendix

Appendix I. Survey

Please rate on a scale from 1-10
1 (uncomfortable) to 10 (very comfortable)

1. At 0% incline with the weight placed high (near shoulders)

1 2 3 4 5 6 7 8 9 10

2. At 0% incline with the weight placed low (near hips)

1 2 3 4 5 6 7 8 9 10

3. At 10% incline with the weight placed high (near shoulders)

1 2 3 4 5 6 7 8 9 10

4. At 10% incline with the weight placed low (near hips)

1 2 3 4 5 6 7 8 9 10

5. Do you prefer the backpack with the weight placed low or high at 0%?

6. Do you prefer the backpack with the weight placed low or high at 10%?

7. Overall do you prefer the backpack with the weight placed high or low?

8. How would you rate your previous backpacking experience?

1 2 3 4 5 6 7 8 9 10
Non-existent Some-experience very experienced

9. In your previous backpacking endeavors, did you place the majority of the weight?
High or Low

Appendix II. Instructions for Rate of the Perceived Exertion Scale

Instructions for Rate of the Perceived Exertion Scale

While exercising we want you to rate your perception of exertion i.e., how heavy and strenuous the exercise feels to you. The perception of exertion depends upon the strain and fatigue in your muscles and upon your feeling of breathlessness or pain in the chest and, in general, your overall feelings of strain and fatigue.

We want you to use this rating scale from 6 to 20, where 6 means “no exertion at all” and 20 means “maximal exertion.”

9. Very Light: It's easy to carry on a conversation while walking at this pace. An example would be a leisurely walk to class with one of your friends with plenty of time to spare. Breathing would be very easy.

11. Light: It's still pretty easy to carry on a conversation. An example would be walking to class at a moderate pace mindful of the time and that your class starts soon. Breathing would be slightly, but noticeably elevated.

13. Somewhat hard: It's not as easy to carry on a conversation, you have to catch your breath in between sentences. An example would be briskly walking to class to avoid being late.

15. Hard: It is difficult to carry on a conversation. An example would be walking to class as fast as you could to avoid being late for an exam. Your legs also begin to feel some fatigue.

17. Very hard: It is almost impossible to carry on a conversation because you are breathing so hard. An example would be if you were really late to an exam and you were running to your class. Legs become very fatigued.

19. Extremely hard: You cannot catch your breath to talk. You are running as fast as you can to avoid being locked have the classroom and getting a zero on your final exam. Your legs are extremely fatigued.

Try to appraise your feeling of exertion as honestly as possible, without thinking amount what the actual physical load is. Don't underestimate it, but don't underestimate it either. It's your own feeling of effort and exertion that's important, not how it compares other people. What other people think is not important either. Look at the scale and the expressions and then give a number. It's just as good to give an even as an odd number.

Appendix III. Houston estimation $\text{VO}_2 \text{ max}$ equation

$$\text{VO}_2^{\text{peak}} = 50.13 + 1.589(\text{PA} - \text{R}) - .289(\text{AGE}) - .552(\% \text{BF}) + 5.863(\text{F}=\text{O}, \text{M}=1) = \text{EST } \text{VO}_2^{\text{peak}}$$

PA-R:

- I. Does not participate regularly in programmed recreation sport or physical activity.

0 Avoids walking or exertion.

1 Walks for pleasure, routinely uses stairs, occasionally exercises sufficiently to cause heavy breathing or perspiration.

- II. Participates regularly in recreation or work requiring modest physical activity, such as golf, horseback riding, calisthenics, gymnastics, table tennis, bowling, weightlifting, or yard work.

2 10 to 60 minutes per week.

3 Over one hour per week.

- III. Participates regularly in heavy physical activity or engages in vigorous aerobic type activity.

4 Runs less than one mile per week or spends less than 30 minutes per week in comparable physical activity

5 Runs 1 to 5 miles per week or spends 30 to 60 minutes per week in comparable physical activity.

6 Runs 5 to 10 miles per week or spends 1 to 3 hours per week in comparable physical activity.

7 Runs over 10 miles per week or spends over 3 hours per week in comparable physical activity.

Appendix IV. Risk Stratification for Fitness Testing

Risk Stratification for Fitness Testing

Name _____ Date _____

1. Question the individual and mark a response for each item.
2. Classify the individual according to ACSM guidelines (Low, Moderate, High Risk)
3. Determine whether to proceed with testing.

- | | | |
|-----|----|--|
| Yes | No | 1. Family history of Heart Disease. Heart complications in father or male first-degree relative before age 55 or before 65 in female first-degree relative |
| Yes | No | 2. Current smoker or quit less than 6 months ago |
| Yes | No | 3. Hypertension. Resting systolic blood pressure > 140 or systolic > 90 or currently taking anti-hypertensive medications. |
| Yes | No | 4. Hypercholesterolemia. Total cholesterol > 200 or HDL < 35 or currently taking medication to lower cholesterol. (If LDL is known use > 130) |
| Yes | No | 5. Impaired fasting glucose. Fasting glucose > 110 or known diabetic |
| Yes | No | 6. Obesity. BMI > 30 kg/m ² or waist girth > 100 cm (39 inches) |
| Yes | No | 7. Sedentary lifestyle. Not participating in regular exercise program. |

Total "Yes" answers _____

Does the individual experience any of the following?

- | | | |
|-----|----|---|
| Yes | No | 1. Pain, discomfort in the chest, neck, jaw, arms, or other areas that may be indicative of a heart problem |
| Yes | No | 2. Shortness of breath at rest or with mild exertion |
| Yes | No | 3. Dizziness or faintness |
| Yes | No | 4. Labored breathing especially at night |
| Yes | No | 5. Swelling, especially at or near the ankles |
| Yes | No | 6. Severe pain in the legs during exertion that goes away with rest |

Yes No 7. Fluttering of the heart or rapid heart rate for no apparent reason

Yes No 8. Known heart murmur (mitral valve prolapse, etc)

Total number of "Yes" answers _____

Based on the answers to the above questions, circle one of the following below.

Low Risk

Younger individuals (men < 45, women < 55) who are asymptomatic and have no more than 1 yes answer from part 1 above.

Moderate Risk

Older individuals (men \geq 45, women \geq 55) OR those who have 2 or more yes answers from part one.

High Risk

Individuals with one or more yes answers from part 2 above or known cardiovascular disease (cardiac, peripheral vascular, or cerebrovascular disease), pulmonary disease (COPD, asthma, lung disease, or cystic fibrosis), or metabolic disease (diabetes, thyroid disorder, renal or liver disease).

Insert ACSM chart for Dr.'s presence here.

Tester _____

Date _____

Appendix V. Informed Consent for Exercise Testing Western Kentucky University
Human Performance Lab

**Informed Consent for Exercise Testing
Western Kentucky University Human Performance Lab**

- **Purpose**

The purpose of this project is to determine if heart rate and feelings of intensity are different when walking on a treadmill and wearing two different types of backpacks.

- **YOU SHOULD NOT PARTICIPATE IF YOU:**

- 1) ARE PREGNANT OR MIGHT BE PREGNANT
- 2) YOU ARE TAKING DRUGS (PRESCRIPTION OR ANY OTHER)
- 3) HAVE A FAMILY HISTORY OF HEART, VASCULAR, OR KIDNEY DISEASE
- 4) HAVE ANY MEDICAL OR OTHER CONDITION EXCLUDING YOU FROM EXERCISING

- **Requirements**

By volunteering to participate you will be asked to do the following:

- 1) Be assessed for
 - A. Height
 - B. Weight
 - C. Body fat percent by:
 1. Females-Measuring the thickness of your pinched skin at the back of the arm, side of your waist, and mid upper leg.
 2. Males- Measuring the thickness of your pinched skin at the chest, your waist, and mid upper leg.
 - D. Aerobic Fitness- a non-exercise estimation
- 2) Walk on treadmill for 30 minute on two separate occasions while wearing a backpack weighing 25% of your body weight
- 4) Estimate how difficult the exercise feels (RPE) based on a scale numbered 6-20

- **Procedures**

- 1) The trials will be completed in two separate lab sessions with at least one day between each test.
- 2) Height and weight will be assessed using basic measuring devices.
- 3) Heart rate will be accessed by a heart rate monitor. This consists of a small transmitter belt being worn around the upper part of the chest.
- 4) Each trial will be a 30-minute treadmill walk with either the backpack weight being heaviest around the shoulders or the hips. The backpack that will be packed to weigh 25% of your body weight.
- 5) The males will walk at 2.5 miles/hr and 2.0 miles/hr for the females.
- 6) You will walk for 15 minutes at 0 % level and at 10% (uphill) for fifteen minutes each.
- 7) You will be asked to rate your intensity based on a numbered scale.
- 8) The trial will conclude after 30 minutes with a five- minute cool down without a backpack.

During testing you may experience fatigue particularly near the completion of the test. It is also likely that you will experience increased breathing, increased heart rate, leg fatigue, other symptoms associated with physical exertion. You are encouraged to indicate to the tester anytime you feel you do not need to or do not wish to continue for whatever reason.

- **Questionnaires**

Prior to participation you **MUST** complete a physical activity readiness questionnaire (PAR-Q), a health risk questionnaire, and the informed consent. These forms will be used to evaluate the safety of your participation as well as your willingness to participate. Any questions you may have about your participation or the forms you complete are welcomed and will be answered to your satisfaction.

- **Risks Due to Participation**

Potential risks to your health and well-being because of your participation include 1) cardiovascular injury (heart attack or stroke), 2) short- term muscular fatigue, 3) lightheadedness, dizziness, nausea, 4) all other possible risks associated with physical exertion.

*The American College of Sport Medicine (2000) suggests the following regarding the potential for risk/injury as the result of participating in an exercise test of this nature

Risk of Death during or immediately after	< 0.01% (1 in 10,000)
Risk of heart attack during or immediately after	< 0.04% (4 in 10,000)

Risk of hospitalization as a result of testing < 0.2% (2 in 1,000)

*Because your health history and current lifestyle habits have been evaluated prior to your participation, your risk is likely lower than those described above.

- **Safety of Participation**

We will take every precaution to ensure your safety. It is very important that you fully disclose anything that would increase your risk for exercise. IT IS IMPORTANT THAT YOU DO NOT CONSUME HEAVY FOODS FOR APPROXIMATELY 3 HOURS PRIOR TO EACH LAB SESSION. DRINK PLENTY OF FLUIDS AND AVOID ALCOHOL FOR 24 HOURS BEFORE PARTICIPATING IN THE EXERCISE TRIALS. ALSO, YOU SHOULD REPORT TO THE LAB EACH TIME WELL-RESTED (NO STRENUOUS EXERCISE FOR 24 HOURS PRIOR TO THE LAB SESSION). Also, do not 1) take medication of any kind, 2) consume any caffeine the days when you are participating, and 3) wear similar athletic clothing to both testing sessions.

IF YOU FEEL ILL AT ANY TIME DURING, BEFORE OR AFTER PARTICIPATION LET THE INVESTIGATORS KNOW IMMEDIATELY!! IF YOU MIGHT BE PREGNANT OR IF YOU ARE TRYING TO CONCEIVE CHILDREN, YOU SHOULD NOT PARTICIPATE IN THE STUDY!!

- **Right to Withdraw**

It is your right to withdraw from participating in the fitness evaluation at any point in time. Withdrawing from the will not adversely affect you in any manner. You should also understand that the investigator might ask you to withdraw from the study.

- **Privacy**

Any information collected about you will be completely confidential. Your participation will not be recognized nor will any personal information about you be made public. Only yourself, the tester performing the evaluations, and the director of the human performance lab will have access to any personal information collected about you.

- **Voluntary Consent**

If you fully understand what will be asked of you (should you decide to participate), please read and sign the following statement:

I freely and voluntarily and without undue inducement or any element of force, fraud, or deceit, or any form of coercion, consent to complete the personal fitness evaluation. I understand that my participation is strictly voluntary and that I am free to withdraw my

consent and discontinue participation at any time without penalty or prejudice. I also understand that my confidentiality will be protected and that my name nor information about me will not be made public. I have been given the right to ask and have answered any questions that I may have regarding my participation. I also understand that any other questions that I may have regarding my participation or any of the associated procedures may be addressed to Katelyn Wells, individual conducting the test and/or Dr. Matt Green in the Department of Physical Education and Recreation (745-6035). I have read and understand the above.

Signature: _____

Date: _____

Address: _____

Telephone #: _____

Witness _____

Date: _____

THE DATED APPROVAL ON THIS CONSENT FORM INDICATES THAT
THIS PROJECT HAS BEEN REVIEWED AND APPROVED BY
THE WESTERN KENTUCKY UNIVERSITY HUMAN SUBJECTS REVIEW BOARD Dr. Phillip E. Myers, Human
Protections Administrator
TELEPHONE: (270) 745-4652

Appendix VI. PAR-Q

Physical Activity Readiness
Questionnaire - PAR-Q
(revised 1994)

PAR - Q & YOU

(A Questionnaire for People Aged 15 to 69)

Regular physical activity is fun and healthy, and increasingly more people are starting to become more active every day. Being more active is very safe for most people. However, some people should check with their doctor before they start becoming much more physically active.

If you are planning to become much more physically active than you are now, start by answering the seven questions in the box below. If you are between the ages of 15 and 69, the PAR-Q will tell you if you should check with your doctor before you start. If you are over 69 years of age, and you are not used to being very active, check with your doctor.

Common sense is your best guide when you answer these questions. Please read the questions carefully and answer each one honestly: check YES or NO.

- | YES | NO | |
|--------------------------|--------------------------|--|
| <input type="checkbox"/> | <input type="checkbox"/> | 1. Has your doctor ever said that you have a heart condition <u>and</u> that you should only do physical activity recommended by a doctor? |
| <input type="checkbox"/> | <input type="checkbox"/> | 2. Do you feel pain in your chest when you do physical activity? |
| <input type="checkbox"/> | <input type="checkbox"/> | 3. In the past month, have you had chest pain when you were not doing physical activity? |
| <input type="checkbox"/> | <input type="checkbox"/> | 4. Do you lose your balance because of dizziness or do you ever lose consciousness? |
| <input type="checkbox"/> | <input type="checkbox"/> | 5. Do you have a bone or joint problem that could be made worse by a change in your physical activity? |
| <input type="checkbox"/> | <input type="checkbox"/> | 6. Is your doctor currently prescribing drugs (for example, water pills) for your blood pressure or heart condition? |
| <input type="checkbox"/> | <input type="checkbox"/> | 7. Do you know of <u>any other reason</u> why you should not do physical activity? |

YES to one or more questions

If
you
answered

Talk with your doctor by phone or in person BEFORE you start becoming much more physically active or BEFORE you have a fitness appraisal. Tell your doctor about the PAR-Q and which questions you answered YES.

- You may be able to do any activity you want—as long as you start slowly and build up gradually. Or, you may need to restrict your activities to those which are safe for you. Talk with your doctor about the kinds of activities you wish to participate in and follow his/her advice.
- Find out which community programs are safe and helpful for you.

NO to all questions

If you answered NO honestly to all PAR-Q questions, you can be reasonably sure that you can:

- start becoming much more physically active—begin slowly and build up gradually. This is the safest and easiest way to go.
- take part in a fitness appraisal—this is an excellent way to determine your basic fitness so that you can plan the best way for you to live actively.

DELAY BECOMING MUCH MORE ACTIVE:

- if you are not feeling well because of a temporary illness such as a cold or a fever—wait until you feel better; or
- if you are or may be pregnant—talk to your doctor before you start becoming more active.

Informed Use of the PAR-Q: The Canadian Society for Exercise Physiology, Health Canada, and their agents assume no liability for persons who undertake physical activity, and if in doubt after completing this questionnaire, consult your doctor prior to physical activity.

You are encouraged to copy the PAR-Q but only if you use the entire form

NOTE: If the PAR-Q is being given to a person before he or she participates in a physical activity program or a fitness appraisal, this section may be used for legal or administrative purposes.

I have read, understood and completed this questionnaire. Any questions I had were answered to my full satisfaction.

NAME: _____

SIGNATURE: _____

DATE: _____

SIGNATURE OF PARENT _____
or GUARDIAN (for participants under the age of majority)

WITNESS: _____



Appendix VII. Data Collection

Name :

M=2.5MPH

F= 2.0 MPH

HIGH weight ratio 3:1:1 / LOW weight ratio 1:1:3

Time	HR	RPE Legs	RPE back	RPE shoulders	RPE overall
3 MIN					
6 MIN					
9 MIN					
12 MIN					
15 MIN					
18 MIN					
21 MIN					
24MIN					
27 MIN					
30 MIN					

HT: _____

WT _____

BF% _____

VO₂ _____

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